ungen der Deutschen Südpolar Expedition 1901 bis 1903," Fr. Bidlingmaier; "Regarding Magnetic Records Obtained in Cooperation with Captain Scott's Antarctic Expedition," C. Chree; "Magnetic Character of Days as Observed at the Cheltenham Magnetic Observatory, April 1 to June 30, 1912," G. M. T., O. H. Tittmann; "The Magnetic Character of the Year 1911," G. van Dijk; "Levé Magnétique der Bassin du Rio S. Francisco," H. Morize; "Observation of the Magnetic Declination at Warsaw during the Solar Eclipse of April 17, 1912," S. Kalinowski; "On the Movement of Inertia of Long Magnet H 26 at the Cheltenham Magnetic Observatory," R. L. Faris; Abstracts and Reviews.

SCIENTIFIC BOOKS

The Influence of a Magnetic Field upon the Spark Spectra of Iron and Titanium. By Arthur S. King. Publication No. 153. Carnegie Institution of Washington.

It is assumed that the readers are familiar with line spectra produced by luminous rays from dissociated particles of the metals. Most readers will also be familiar with the following fact, viz., when these lines are produced in a magnetic field they break up into three or more components. This is called the Zeeman effect.

By reason of Hale's epoch-making discovery of a Zeeman effect in solar lines, this phenomenon has come to have a large interest to astrophysicists as well as to physicists. This iron and titanium study should particularly appeal to the former.

The Zeeman effect is much more complicated than the simple theory first indicated. The separations differ in magnitude, number of components, relative spacing of the components, relative intensity and relative sharpness. Farther, the intensity of some of the components is relatively increased (enhanced) with respect to the original line, others are relatively decreased. All of these items are important in the determination of spectral series and in arriving at the physical condition of the luminous particles. Each spectral series generally shows but one type of separation. Furthermore, some of these types repeat from substance to substance, showing an intimate electronic relationship in the molecule of different substances. The phenomenon grows very complex in the detailed study of the different elements. The "Zeeman effect" and spectral series stand almost alone in showing us what a wonderful complex structure exists within every atom. Not all the complexities of the phenomena have been explained. Still, theory has kept well apace with the observations and has often pointed out the way. So important in the latter respect has been some of the contributions by Ritz, that I should like to add at least one of his contributions[1] to the very complete bibliography given by Mr. King.

While all the above characteristics are important no observer has recorded them all, not caring to encumber his data with detail which is not immediately fruitful. Likewise there is much curtailing of the computations. In a paper published by the Carnegie Institution, it seems to me that items of possible future as well as present value might be recorded and save a great amount of labor.

The components of many lines lie so very close together that it is necessary to separate the two kinds of vibrations by some polarizing device, and photograph each separately. The very important relation of the intensity of these kinds of vibration can not then be found accurately since it is impossible to maintain light at the same intensity for the two exposures. But it occurs to me that, with the non-astigmatic Littrow spectroscope which Mr. King has used, one could focus the double image of an interposed calcite upon the slit and photograph both kinds of vibrations coincidently in juxtaposition.

Particularly among the several component lines, there seems to be a certain degree of order. They are often stepped off in uniform spaces. These steps differ in magnitude from line to line, but all seem to be simple fractional parts of a standard value, called the normal, *a*. Furthermore, this "normal" has the value we should expect from the ratio of

[1] *Ann. d. Physik*, 25, 660, 1908.

electrical charge to the mass of the simple electron. This has been interpreted to mean that the rotating (vibrating) electron does not produce an appreciable magnetic field but that the complexity arises from "linkage" of the electrons in different ways. I will illustrate this simplicity of step arrangement by citing from Mr. King's work three iron lines, viz., 3722.7 λ, 3872.6 λ and 5447.1 λ. The spacings are all "normal" and the steps are (1, 2, 3, 4) for one kind of vibration and 1, 2, for the other kind of vibration so that King writes the line $\pm$ (1, 1, 2, 2, 3, 4) a. From his tabulated measurements I have computed the value a, and find it for the three lines to be respectively $.730 \pm .008$, $.752 \pm .006$ and $.758 \pm .006$, whereas his field strength would give .753. One notices but a slight deviation in the first, which arose from a probable error in one measurement. These little details in computation may add much to the conclusiveness of a statement. Neither such simplicity nor so conclusive a relationship is present in the twelve component thorium line 4086.7 λ.[2]

For most substances the majority of lines are triplets, which corresponds to the simplest form of the theory developed by and predicted by Lorentz. However, these triplets show great variety in magnitude and appearance.[3] Mr. King thinks there is some tendency for these lines to group about magnitudes related to the "normal." For example, he finds that thirty-five sharp lines (Table IV.) can be grouped under the magnitude $3a (= 2.26)$. I find twenty of these lines to lie between 2.21 and 2.32 with an average of 2.275. This is a difference of five per cent. in the extremes. For a considerable distance upon either side of this space (2.21 to 2.32) there are but few lines of corresponding sharpness. This fact seems favorable to a single group in this list. But the real necessity here is the same as I pointed out in case of thorium, viz., a little greater accuracy (or greater resolving power of the spectroscope). For example, reduce this extreme error in variation from five to one per cent., possibly even two per cent., then we shall know whether there are steps in the magnitude of the triplet separations or whether there are a great variety of separations differing by small increments of value. The latter result implies that the electrons are vibrating in a self induced, as well as the superimposed magnetic field.

I fail to see the validity of Mr. King's law (p. 54): "*Since* $D\lambda/\lambda^2$ (*i. e.*, change in frequency of vibration per sec.) *is shown to be nearly a constant, . . . the mean separation of the n-Components* (*i. e.*, components which vibrate perpendicular to the lines of force) *varies as the square of the wave length.*" The notes in parentheses are added by way of explanation. One thing made certain by experiment and theory is that different types of separation correspond to different physical aggregates, unions, or "linkages" of electrons; and Preston's law shows that any *single type* may repeat itself in lines throughout the spectrum, according to this *very* law that King enunciates. That the mean of all types should give a uniform value throughout the spectrum, implies only that all types are fairly well distributed throughout the spectrum. Such a statement has no particular value. For in a chance distribution, by the law of probabilities, such uniformity must increase as the number of lines increase. Mr. King's Table VII. shows this.

The most important place in Mr. King's paper is given to a discussion of the relation of the magnetic separation to a displacement in the position of the spectral lines which arises when the radiating particles are subjected to an external pressure. The latter is a well-known phenomenon. However, no explanation of it has found extended acceptance. Humphrey's theory involves a strong magnetic field induced by the rotating electrons. As observed above, such a field is by no means certain. But this theory and the prominence of both phenomena in solar lines form the principal reasons for an examination of their possible relationship. Tables XI. and XII. show the ratio of the two quantities for different lines to vary twenty-five fold. Then at

[2] *Astrophysical Journal*, XXX., p. 151, 1909.

[3] See King's references to Purvis, Moore, Jack, Cotton and Babcock.

once one would infer there is no relationship between the phenomena. However, Mr. King analyzes the lines by subdividing them into groups, and concludes "that a close correspondence does not exist, but there is a general agreement as to magnitude of the two effects when the means of a large number of lines are considered." I should like to add, that the "means of a large number of lines," leaves much to be desired in the proof of a relationship. Mr. King's method of subdivision carries with it another suggestion. When he divides the separations into small, medium and large, he reduces the number of types of separation in each class. For clearly a line whose separation is small does not belong to the same type as one whose separation is large. Again he selects the ratio of each of three subdivisions to low, medium and high displacement respectively. This gives arbitrarily nine divisions. By this method he shows there is an approach toward uniformity in relative magnitude. The suggestion is, what may we expect when these groups are broken up into real series types? Comparing the three iron lines mentioned above gives nothing of promise, although close measurement may show two of them to agree. But in the absence of an established series one can not affirm that these lines belong together. If this point has any merit, it would be worth while to compare substances among whose lines definite series have been established.

The tabulated data for the author's two substances lack just one thing, viz., the ultra-violet spectrum, to make them the most complete study which has appeared.

B. E. Moore

University of Nebraska,
August, 1912

Introduction to General Thermodynamics. By Professor Henry A. Perkins, Trinity College, Hartford. Wiley and Sons.

Recognizing the lack of suitable text-books in English on thermodynamics for students of physical chemistry, the author in writing this book has attempted to make good the deficiency.

The volume comprises some 225 pages of octavo size subdivided into eight chapters, the titles of which in order are: General Heat Relations; The First and Second Laws of Thermodynamics; Entropy; Thermodynamic Equations; Perfect Gases; Real Gases; Change of State; The Solution of Problems. At the end of the book there are eight tables giving gas constants, thermoelectric and calorimetric constants of certain substances, density and thermo-elastic coefficients of certain liquids and solids, critical and Van der Waals constants, coefficients of expansion of gases and relation of pressure units in various systems.

The methods of presentation and demonstration employed by the author are for the most part classical and it is therefore unnecessary to refer to them specifically. The emphasis laid upon the doctrine of available energy as a means of interpretation of the second law is notable. The various thermodynamic potentials and the phase rule of Gibbs receive appropriate attention. The last chapter is noteworthy on account of the large number of problems which are proposed for solution by the student. Solutions of typical problems are given.

The scope of the book appears to be quite adequate for the purposes which the author has in view. A remarkable amount of material is condensed into a small volume through the aid of mathematical expressions; and although the demands made upon the mathematical knowledge of the reader are not very great it would appear that the author probably intends the book to be used by students having the advantage of a competent instructor. Professor Perkins has, in writing this book, furnished a valuable addition to the English text-book literature of thermodynamics.

A. P. Wills

Astronomy in a Nutshell. By Garrett P. Serviss. Illustrated. G. P. Putnam's Sons. 1912. Pp. xi + 261.

There are so many excellent popular books on astronomy and its different branches, that